Summer 2015

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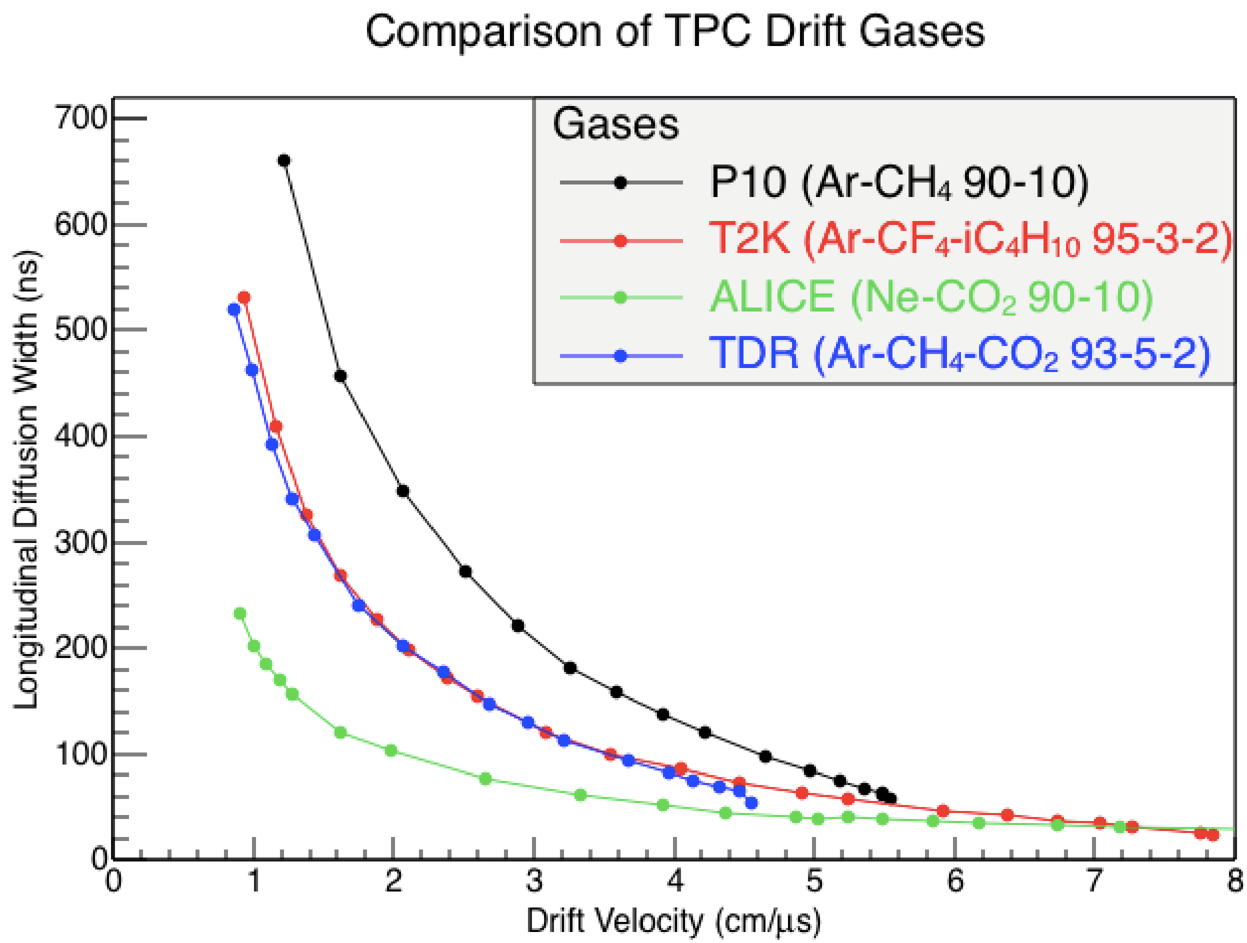
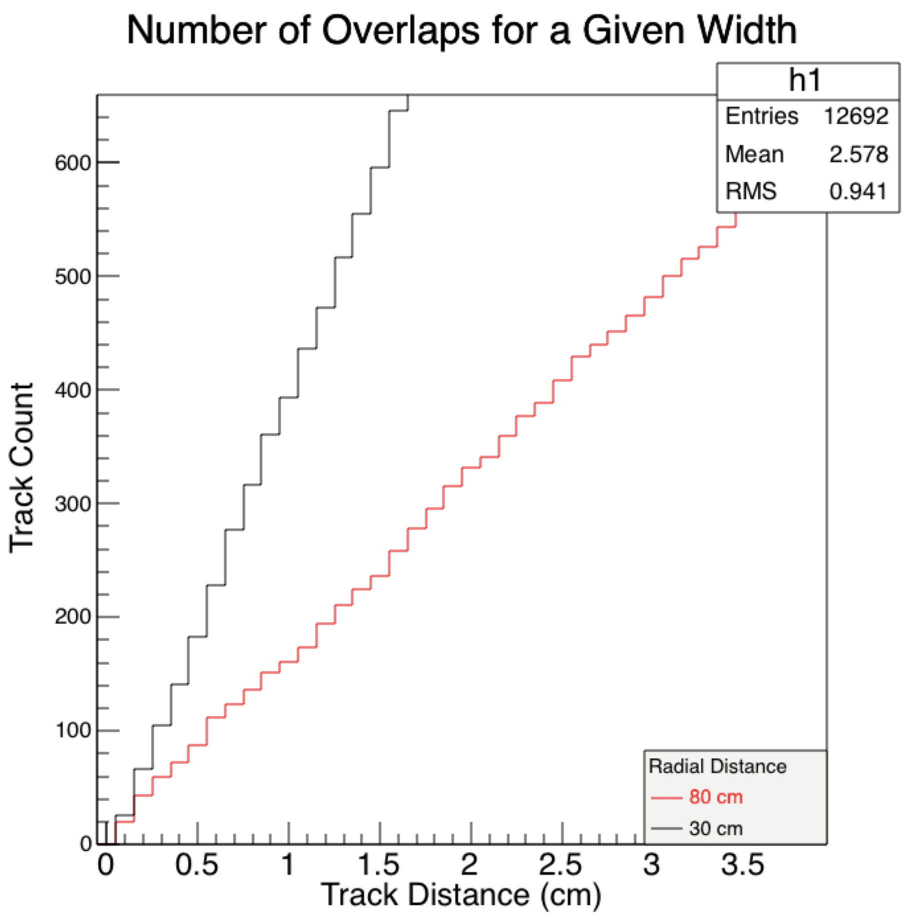
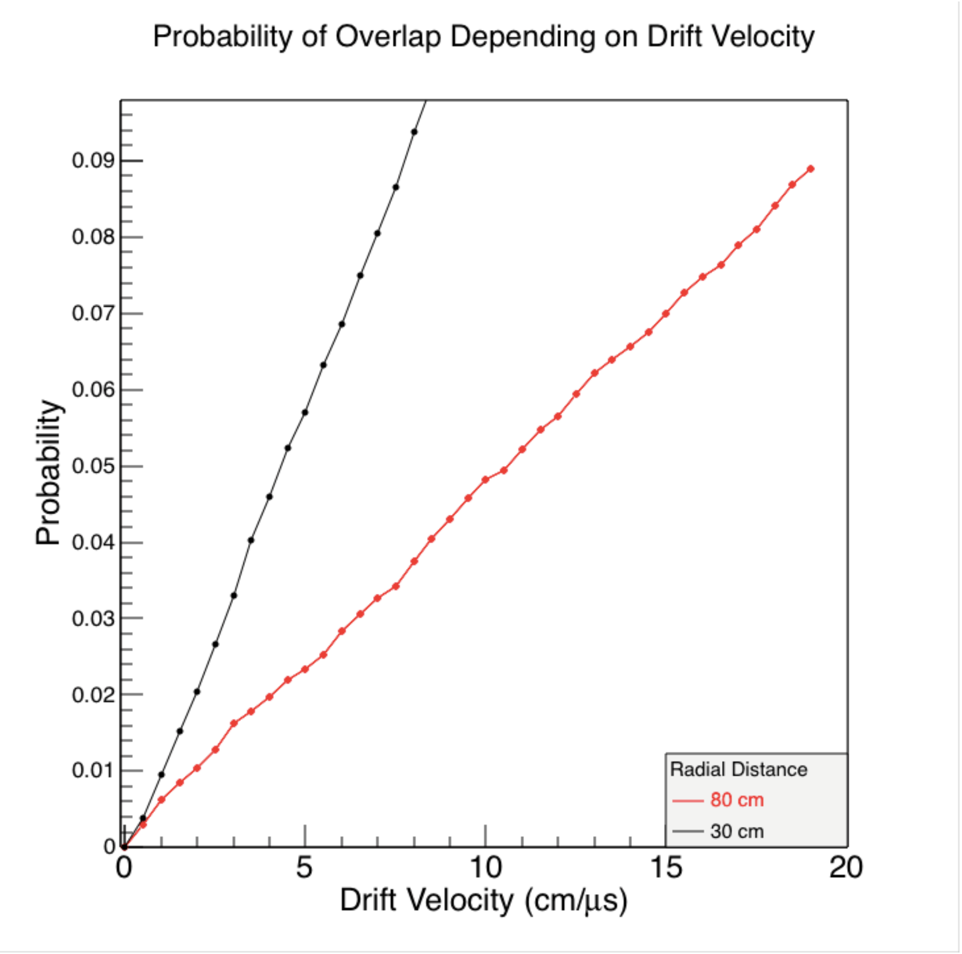
A lower limit estimate on drift velocity was calculated by using distance = diffusion contant * √80cm and time = distance / drift velocity. Data on diffusion constants and drift velocities were taken from a database suggested by Klaus.



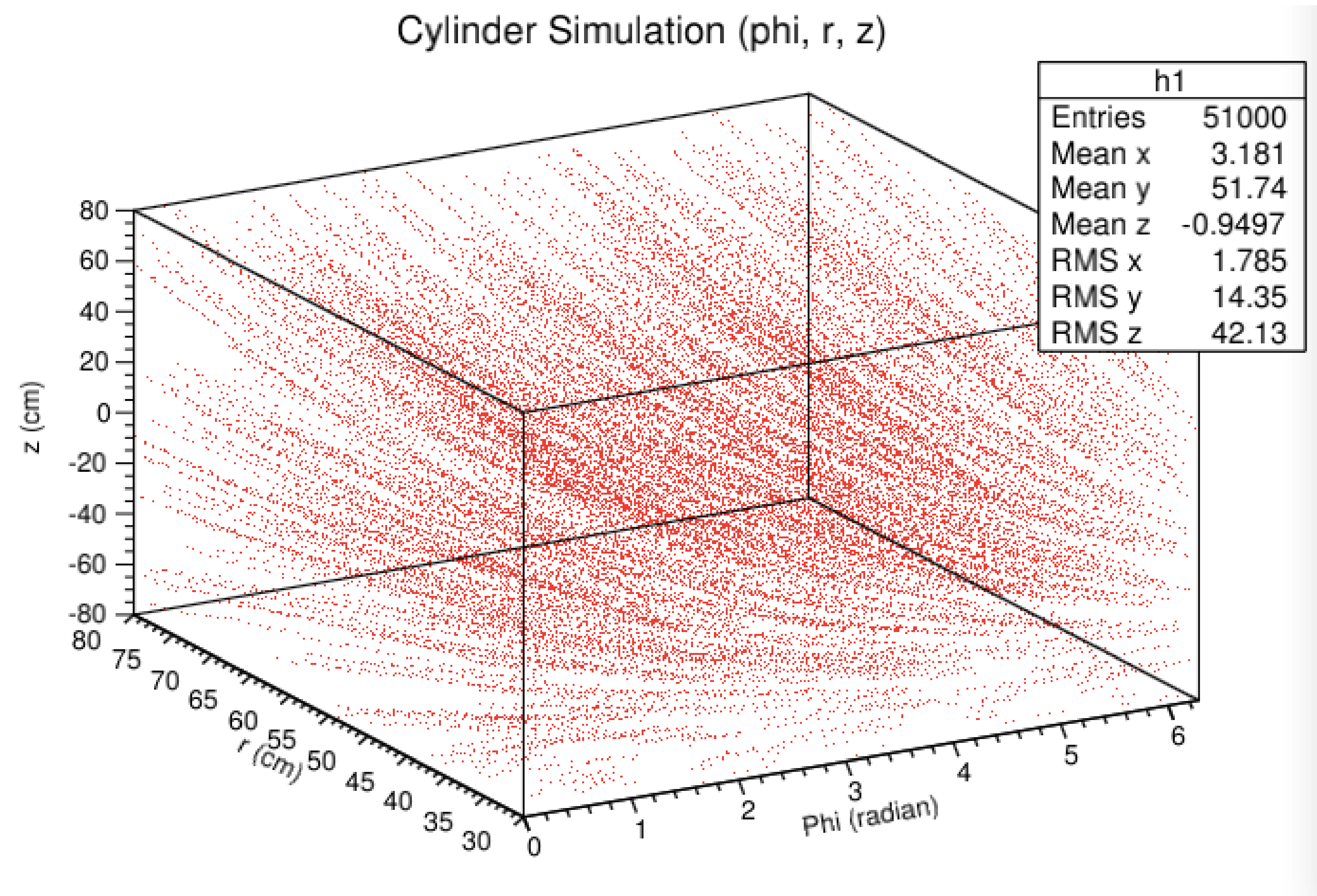
Finding the upper limit on drift velocity began with counting how many tracks would be considered "overlapping." If two tracks are a certain track distance apart, they are considered overlapping. This graph shows how the number of track counts linearly increases as the track distance increases. The tracks were created with a Monte Carlo simulation of tracks distributed randomly along the z axis for each phi (azimuthal) bin.



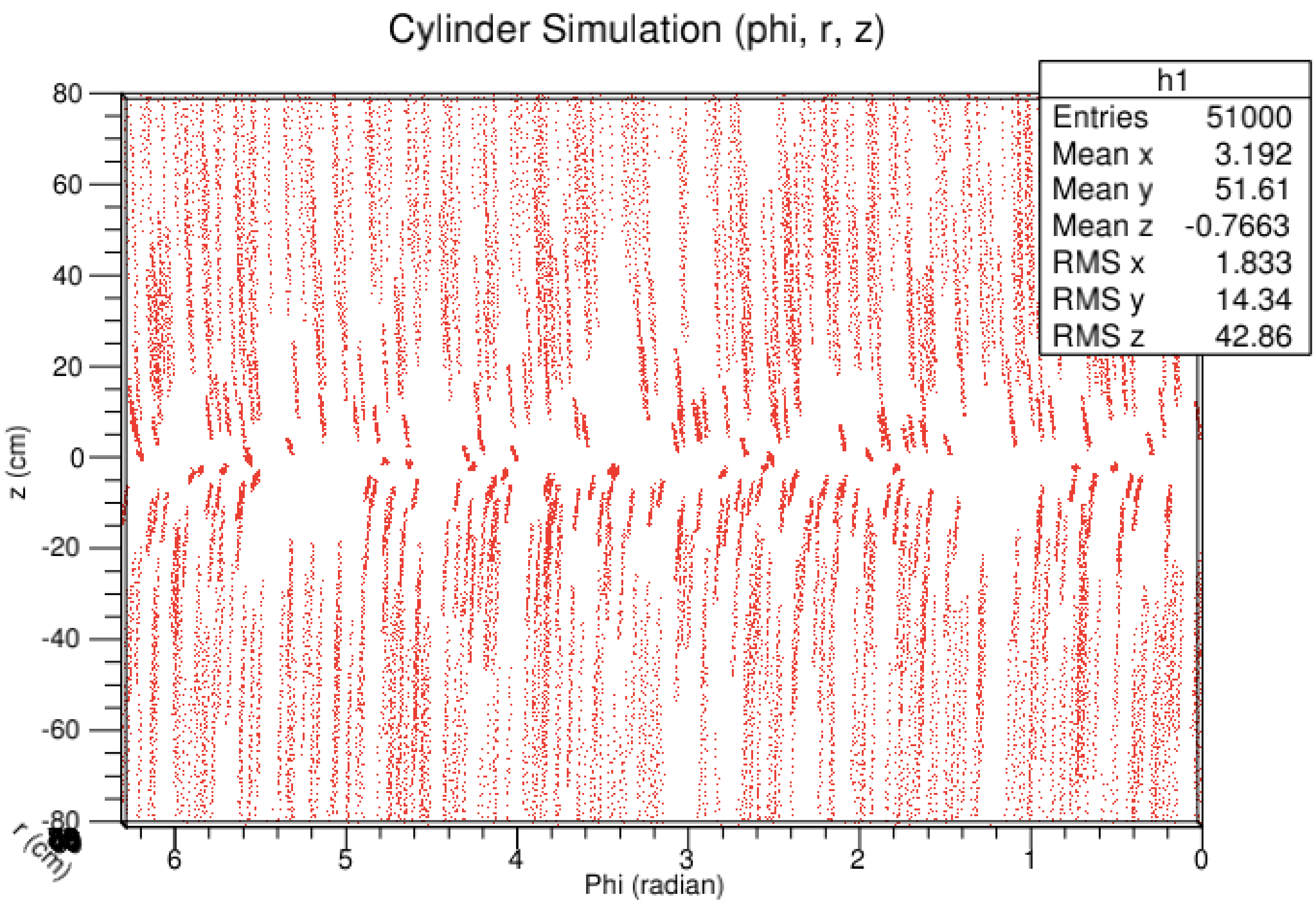
Probability of overlap was calculated by dividing the overlapping track count at each width by the total number of tracks. Drift velocity was calculated by dividing the width by 200 ns (the approximate read out time).



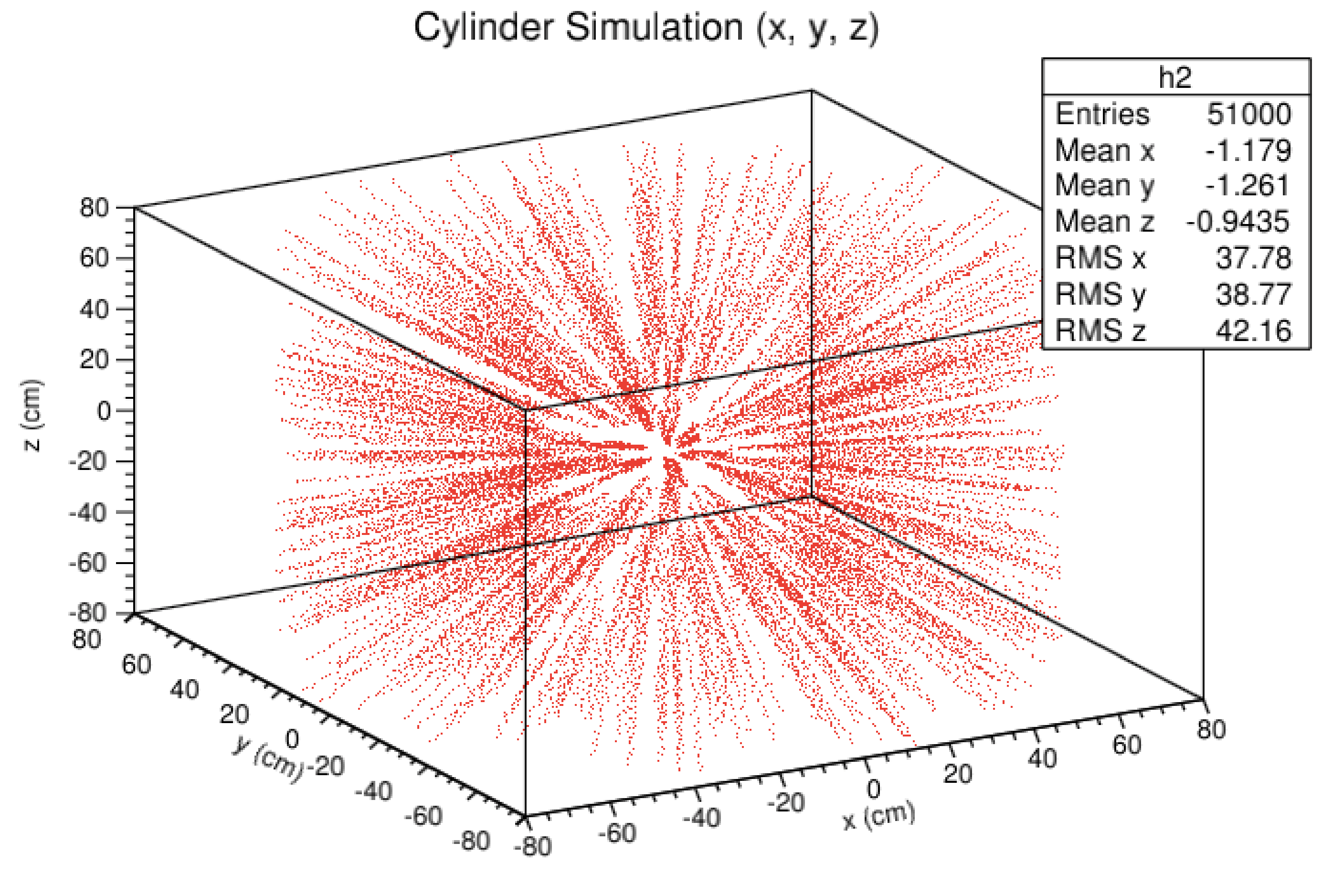
A Monte Carlo simulation of tracks distributed randomly in phi and theta. Theta was restricted to $20° \leq \theta \leq 160°$ (or roughly $-2 \leq \eta \leq 2$). The axes are in cylindrical coordinates.



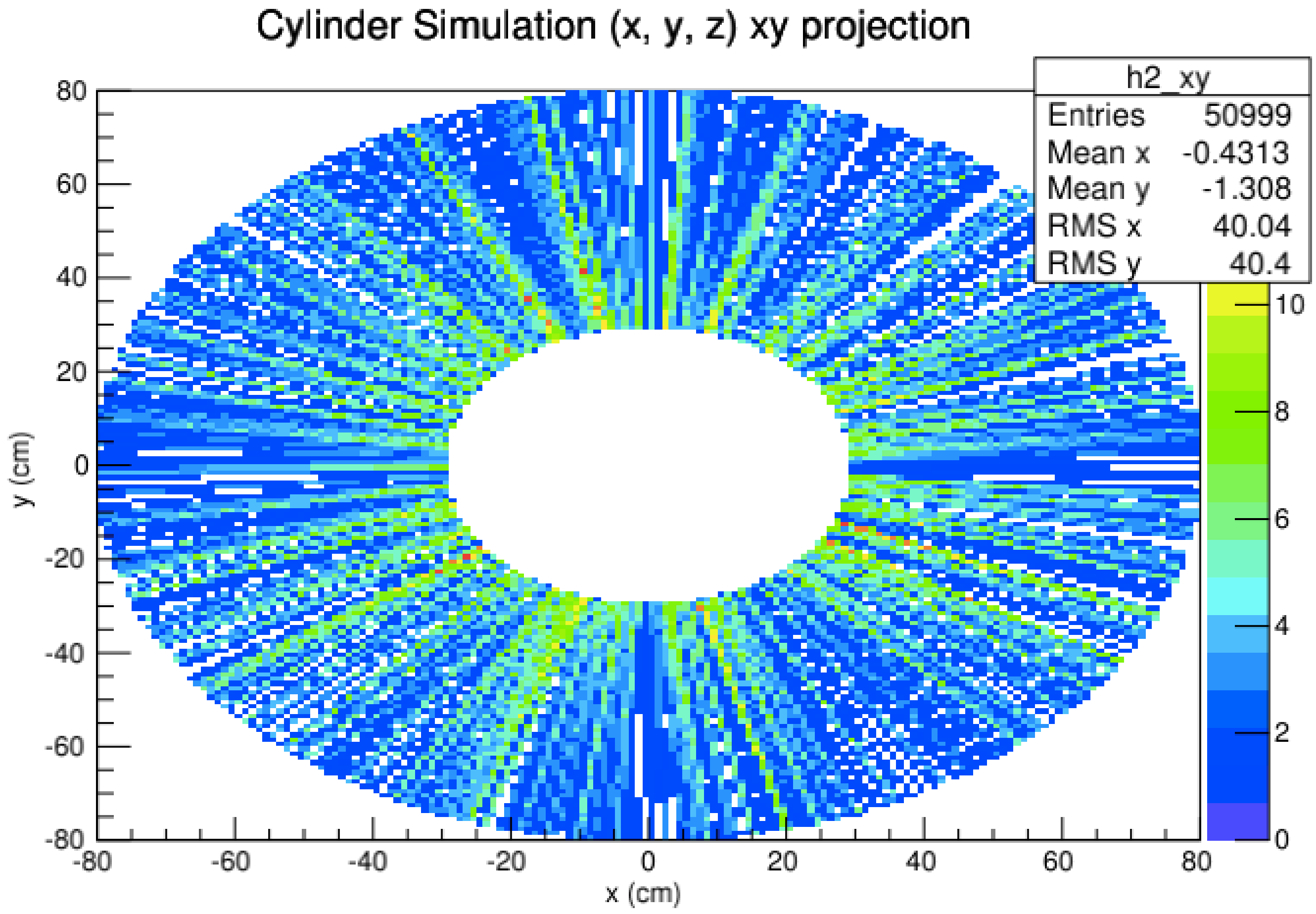
A projection of the cylindrical coordinate simulation on the the z, phi plane. The density is least around z = 0 because the fewest number of tracks pass through z = 0.



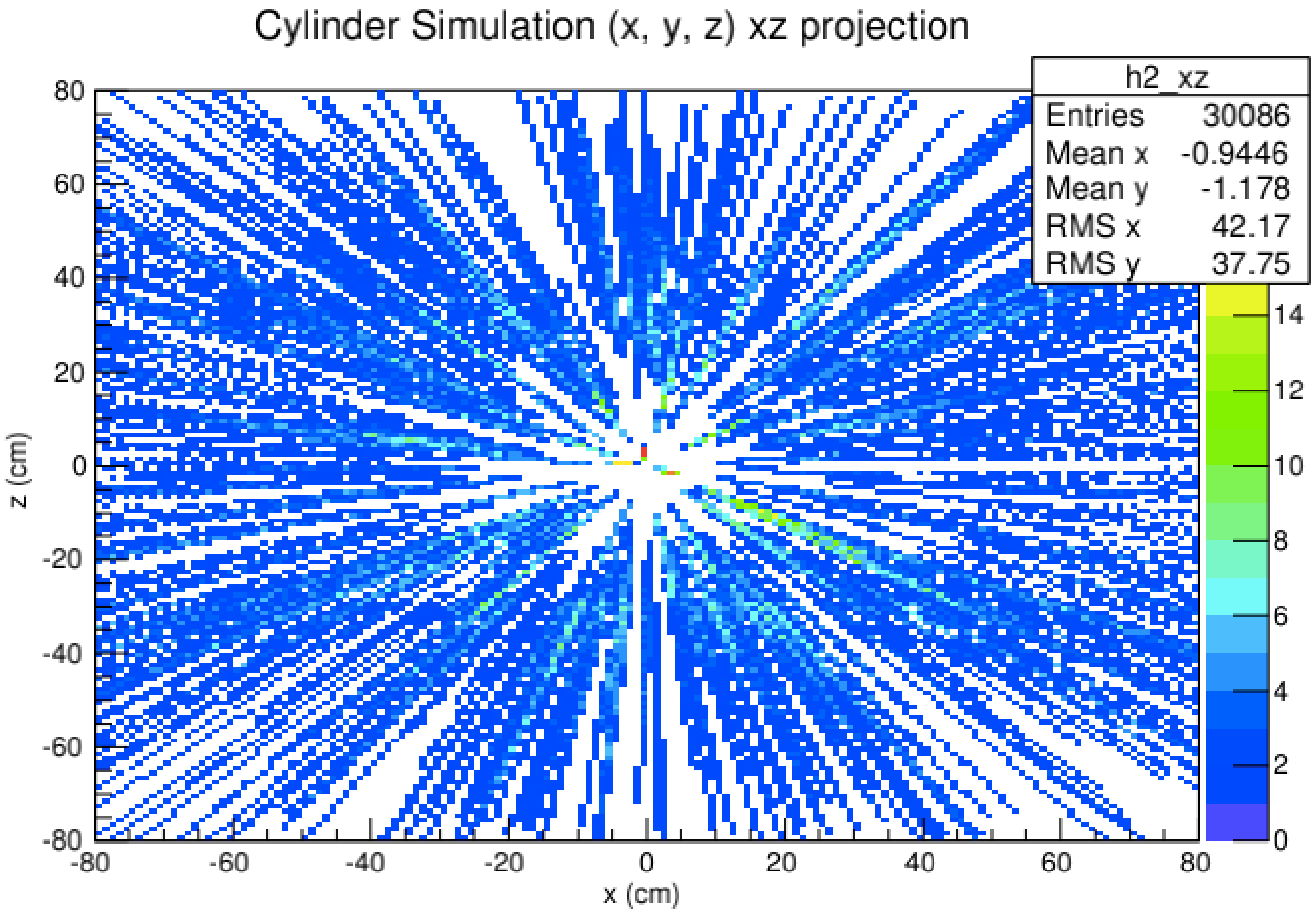
The same Monte Carlo simulation, except in Cartesian coordinates. The tracks appear to be randomly distributed in every direction, as expected.



A projection onto the xy plane of the randomly distributed tracks. The radius is restricted to 30cm ≤ r ≤ 80cm. The density of tracks is greater at a smaller radius, as expected.

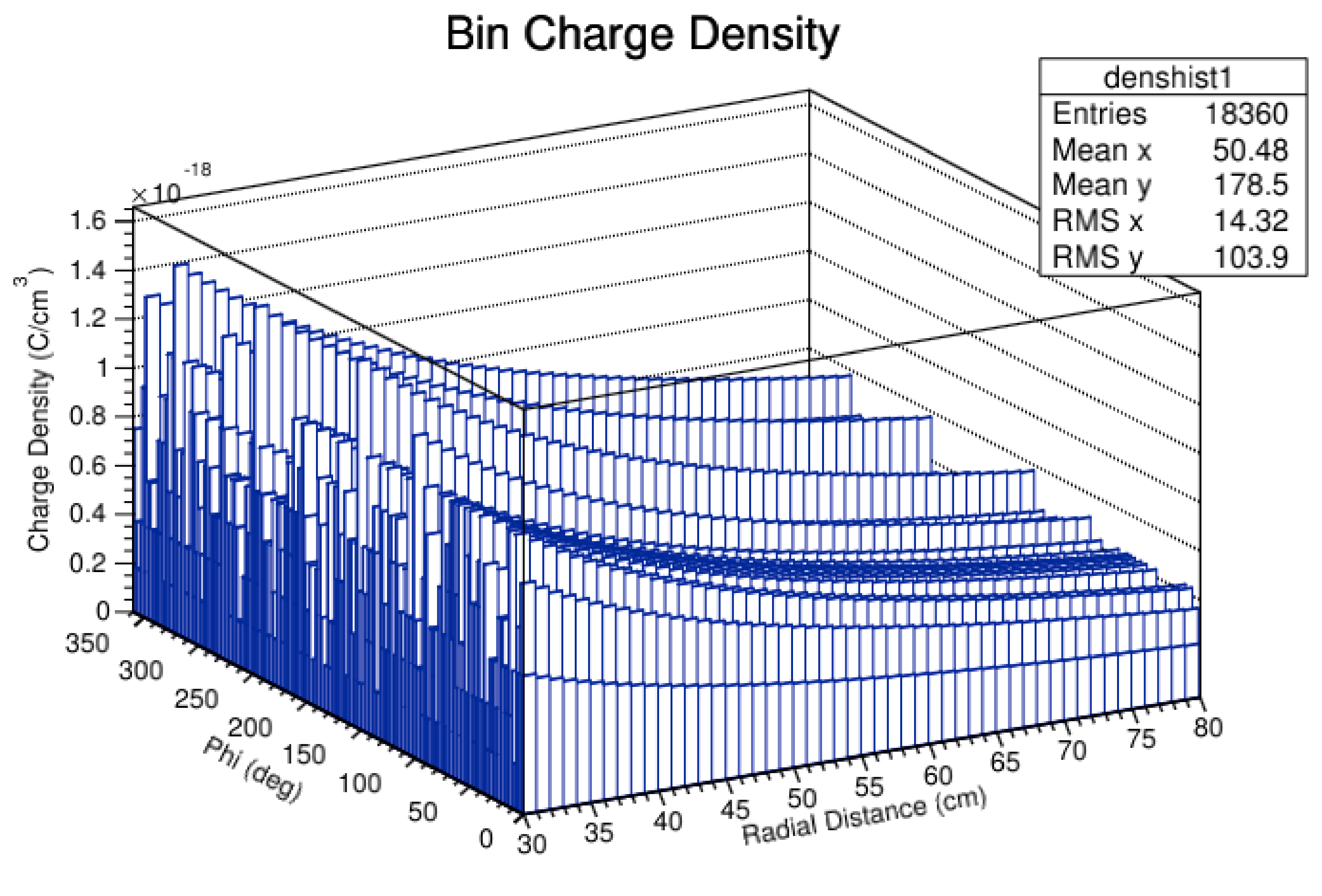


A projection onto the xz plane of the randomly distributed tracks. The center is relatively empty because the fewest number of tracks pass through z = 0 and the radial distance is restricted.

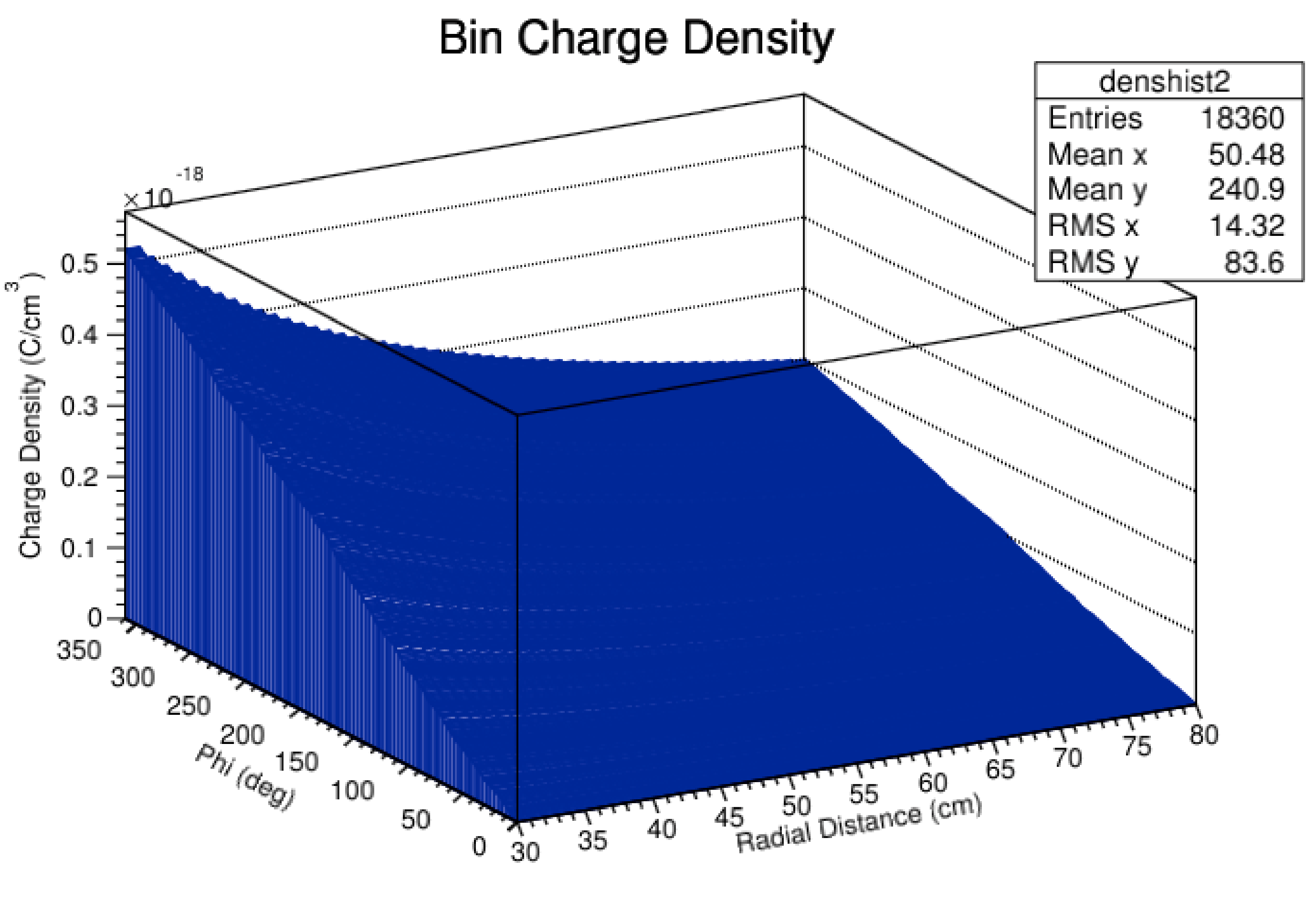


- In the next section I attempt to get an estimate on the electric field caused by the accumulation of ions in the TPC. I tried a 3D calculation but I had trouble with Root. So, in the end I had to project all the charge onto an r, phi plane and ignore fluctuations in z.
- The first graph displays the calculation of charge density for each r, phi bin. In the second graph I then integrate the bins over phi to get a ring charge density dependent on only r.

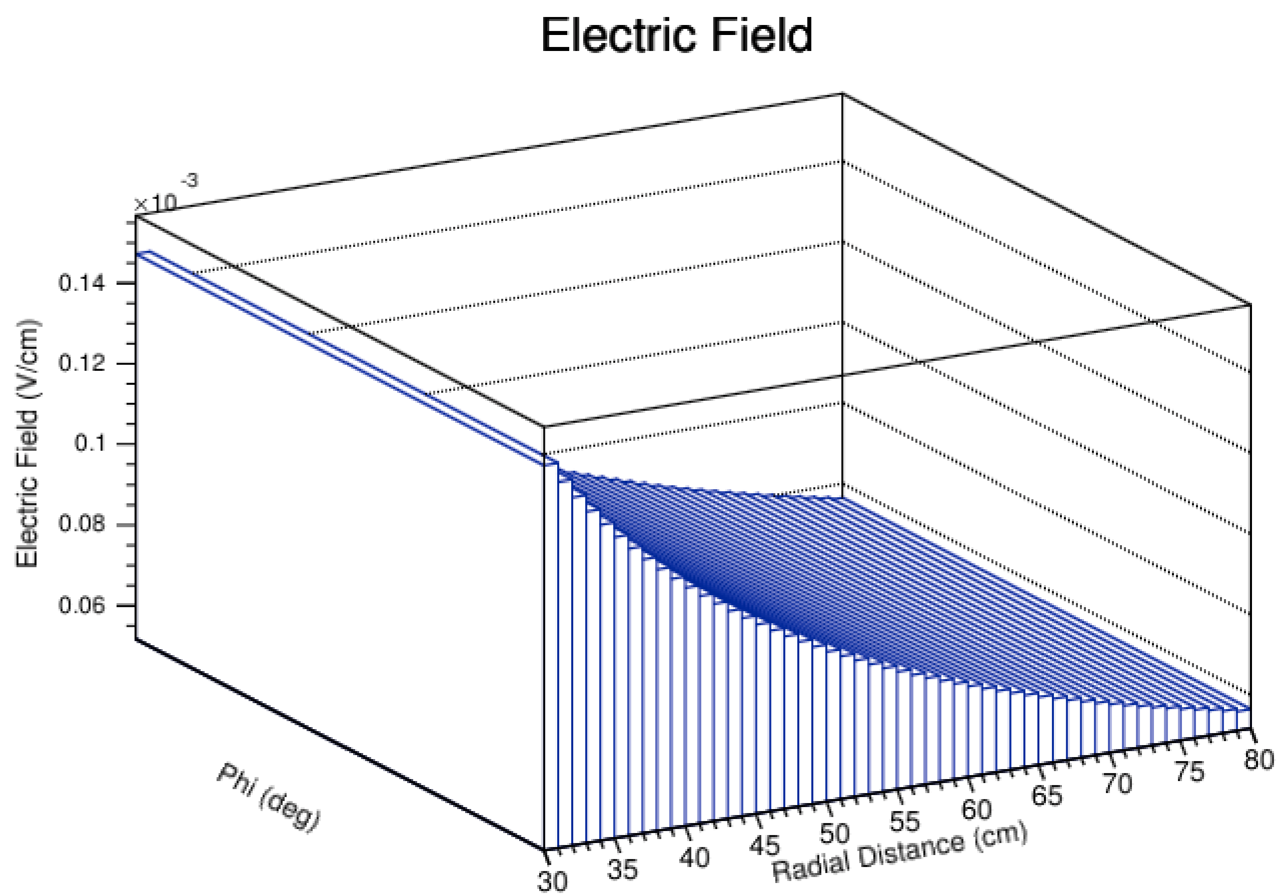
Bin charge density depending on phi and radial distance. The fluctuations in phi are random and occur because this is only a single event. The gas is assumed to create electron-ion pairs at a rate of 100e/cm.



Integration of bin charge densities over phi to get a radially symmetric ring charge density. The charge density increases in phi because the macro adds up the density as it loops through phi. Therefore the last value (360°) is the total ring charge density.



Using the ring charge density and the assumption of a basic infinite-wire type electric field, I calculated a rough estimate of the electric field distortion caused by ions at each r. There is no fluctuation in phi because the charge is assumed to be uniform about phi.



Calculation of the Electric Field

- Using a cylindrical Gaussian surface and treating the cylinder as an infinite wire, the formula for the electric field for 30cm $\leq r \leq$ 80cm turned out to be $E(r) = 25/\varepsilon_0 * \rho(r)$, where $\rho(r)$ is the ring charge density.
- I also did a quick calculation of an electric field about a thin, infinite wire. Assuming that the wire carries the same amount of charge per unit length as there is charge in the TPC for 30cm $\leq r \leq$ 80cm for all phi, at 80cm the electric field comes out to the same value.

Number of Ions in the TPC

- To get an estimate on the number of ions in the TPC, I used the mobility of ions in an Ar-CH4 gas mixture. Klaus sent me a chart with data for certain gas mixtures. Given a mobility of 1.87 cm^2/V.s, the drift velocity can be found by v = mobility * E. For an electric field of 300 V/cm, for example, drift velocity = 561 cm/s = 5.61e-4 cm/μs. If the TPC is 80cm from the center to a readout plane, then it takes ions ~143000 μs to drift from one side to the other. At a collision rate of 15 kHz, this amounts to ~2100 collisions worth of ions in the TPC. Obviously the value depends on the electric field and gas mixture, but the number should be ~10^3.